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VOLUME VI

Sediment Cores from the West Pacific

FASC. II

GÖTEBORG
ELANDERS BOKTRYCKERI AKTIEBOLAG

REPORTS OF THE SWEDISH DEEP-SEA EXPEDITION. VOL. VI
SEDIMENT CORES FROM THE WEST PACIFIC. NO. 2

CHEMICAL ANALYSES OF CORES FROM THE CENTRAL AND WEST EQUATORIAL PACIFIC

BY

G. R. BERRIT AND H. ROTSCHI

This study reports the results of chemical analysis of sediment cores collected from the Equatorial part of the Central and West Pacific. All 27 cores, on average 10m long contained red clay, radiolarian ooze and globigerina ooze. Cores from the western part of the region investigated showed more or less important terrigenous deposits.

Collection and Preliminary Treatment of Samples

The treatment of the cores aboard the ship immediately after their collection, as well as the preserving methods employed, were published in detail by G. ARRHENIUS (1952). The samples, usually cut out at space intervals of 10cm and with an average thickness of 1.5 cm, were ground, and dried at 20° C in air of 60 % humidity. They were then put into glass tubes which were closed with corks. The temperature of 20° C and the saturation of 60 per cent representing ordinary laboratory conditions, the changes in weight during storage are unimportant and may be neglected when correction factors such as water content and salinity are calculated.

Determination of $CaCO_3$, C, N, P_2O_5

The determinations of carbonate, carbon, organic nitrogen and phosphate contents were carried out in the laboratory of Dr. O. ARRHENIUS (Kagghamra, Sweden) under the supervision of Dr. G. ARRHENIUS & MRS. B. SCHWAB. The methods used have been thoroughly described by G. ARRHENIUS (1952), but we shall here briefly repeat the principles:

Carbonate. The sediment is submitted to the action of hot diluted phosphoric acid. The carbon dioxide thus released is collected in a gasometer and its volume is evaluated.

Organic Carbon. The same method is used as for the determination of $CaCO_3$. The residue from the phosphoric acid action is treated by boiling with a solution of potassium iodate in concentrated sulphuric acid. The carbon dioxide derived from the oxidation of organic carbon is collected and volumetrically measured.

Organic nitrogen. A modification of the methods »micro-Kjeldahl» described by PREGLE-GRANT is employed.

Phosphate. The method is based on the colorimetric determination of ammonium phosphomolybdate described by BELL and DOISY, modified by O. ARRHENIUS.

Determination of Iron, Manganese and Nickel

For the red clay and the radiolarian ooze the iron, manganese and nickel analysis have generally been carried out at 10 cm. intervals. For the callcareous terrigenous sediments, larger space intervals up to 50 cm in some cores, were chosen.

The cores analysed at 10 cm intervals are the following:

73, 76, 77, 83, 85, 86, 87, 88, 89, 95, 98, 99, 100, 101, 103.

At every 20 cm:
69, 70, 71, 72, 75, 93, 97, 105.

At every 30 cm:
106.

At every 50 cm:
74, 91, 96.

The analysis had in view the iron, manganese, and in certain cores nickel content.

Nickel was measured in the following cores: 69, 70, 71, 72, 73, 75, 77, 83, 85, 86, 87, 88, 98, 101.

Iron, manganese and nickel were measured colorimetrically in the same solution obtained by treating the sediment with hot concentrated HCl.

Dissolution

A quantity of sediment, 0.5—2 g (according to the calcareous content) is weighed and dried for 24 hours in the drying room at 105° C, receptacle used for weighing, is emptied into a beaker of 150 ml and is rinsed with 10—15 ml HCl 1/3. This solution is evaporated on a sand bath and about 10 ml concentrated HCl is added twice to the dry residue thus rendering the silica insoluble. The treatment is continued with a mixture of 2.5 ml concentrated nitric acid and 2.5 ml concentrated perchloric acid until abundant white fumes are released. The latter procedure is repeated three times. Dissolved in HCl 1/3 on the sand bath, the filtrate is washed in hot HCl 1/3 and diluted to 100 ml.

Colorimetric Analyses

Iron. The thiocyanate method was chosen in spite of its disadvantages, because it is simple and rapid. This method is described by SANDELL (1944). The red colour produced by iron oxide in acid medium with potassium thiocyanate which can be used in strongly acid solutions is employed. As the colouration obtained depends on the excess of thiocyanate and of the amount of acid present in the solution, it is important that exactly the same SCN^- ion concentrations are used for each measurement as well as for the standardizations. The sensitiveness of the method is improved by an excess of thiocyanate and the colouration in this case is less dependent on the pH. In order to avoid a partial iron hydrolysis the pH should, however, be moderate. As the iron thiocyanate complex does not strictly follow BEER's law, it is an advantage always to operate with an approximately constant quantity of iron. The colour of the solution when exposed to light tends to fade, which is due to the partial reduction of iron by thiocyanate or its decomposition products. Furthermore, a slow reaction between thiocyanate and nitric acid causes the formation of a yellow-brown colouring. It is therefore advisable to make the reading of the extinction immediately after the colouration appears.

The course of the analysis is as follows: to a volume of the solution to be analysed, containing 0.1—0.5 mg iron, 1 ml fuming nitric acid is added in order to oxidize the ferrous iron. For some minutes the solution is boiled and then cooled. Then 10 ml of a solution 0.1 N HCl and also, 10 ml of a solution of 10 per cent KSCN is added; it is diluted to a final volume of 100 ml. Five minutes after the addition of thiocyanate, the extinction at 470 mμ is measured in the BECKMAN spectrophotometer. Likewise, the standardization curve is established by reading the extinction five minutes later, delay which represents the necessary time for the manipulations between the adding of the reagent and the reading of the extinction. Some samples have been examined with th aid of ZEISS-PULFRICH photometer and filter S. 53.

Manganese. The method employed has been described by NYDAHL (1949). The manganese is oxidized to permanganate and the intensity of the colouration is measured. The oxidizing agent used is ammonium persulphate with silver nitrate as a catalyst. The presence of phosphoric acid prevents the precipitation of manga-

nese dioxide. The addition of some mercuric ions is a precaution against the silver chloride which may be produced by Cl ions. The colouration is very rapidly developed and as long as there is an excess of persulphate it is quite stable. The procedure is as follows:

In order to eliminate Cl ions the amount of solution to be analysed, containing 0.10—0.50 mg manganese, is evaporated to dryness on the sand bath; this elimination is completed by re-collecting the dry residue with some concentrated nitric acid and again evaporating to dryness. The residue is dissolved in water to which is added 4 ml of the following catalytic solution containing per liter:

75 g mercuric sulphate
400 ml concentrated nitric acid
200 ml 85% phosphoric acid
0.034 g silver nitrate

then about 2 g ammonium persulphate is added to the solution which is heated till boiling point, cooled and diluted to 100 ml. The extinction is measured by means of the BECKMAN (525 mμ) or by the PULFRICH (filter S. 53).

Nickel. The nickel is studied by the colouration it gives with dimethylglyoxime. The method has been described by SANDELL (1944); 10—25 ml of the solution, corresponding to a quantity of nickel of some tens of γ, is used. at first the nickel is extracted, in order to avoid the perturbations of colour due to cobalt, aluminium and manganese. The nickel, together with the dimethylglyoxime in a slightly alkaline medium, gives a specific red-brown colouration. The sensitiveness of the reaction is very high. The colouration develops immediately after the addition of dimethylglyoxime and it remains stable for at least 15 minutes. Thereafter it has a tendency to decrease slowly. The procedure is as follows:

To a part of the solution containing 20—50 γ nickel is added 5 ml of an aqueous 10 per cent solution of sodium citrate in order to avoid the precipitation of iron and aluminium. Neutralization is obtained with concentrated ammonia until the litmus paper turns blue. 2 ml of a 1 per cent dimethylglyoxime solution in alcohol are added. The complex dimethylglyoxime is extracted three times in chloroform. The extract is washed with 5 ml ammonia 1/50 and the complex is destroyed by stirring it twice with a solution of 0.5 N. hydrochloric acid. The nickel enters into the hydrochloric solution and the dimethylglyoxime remains dissolved in the chloroform. Bromine water is added to the hydrochloric extract for its oxidation, then concentrated ammonia until the bromine colouring disappears. 0.5 ml 1 per cent alcoholic solution of dimethylglyoxime is added. The colouration appears at once; the extinction at 520 mμ is measured after dilution to 100 ml.

Verification and Control of Iron, Manganese and Nickel Analyses

The study of errors concerned:

the reliability and precision of the colorimetric determinations,

the reliability of the hydrochloric acid extraction,

the completeness of the iron, manganese and nickel dissolution by the hydrochloric acid.

Accuracy and Reliability of the Colorimetric Determinations

Iron. If the indications of acidity, time of development of the colour and concentration of reagents are observed, and if the concentration limits 0.1—0.5 mg iron in 100 ml of final colorimetric solution, are maintained, the absolute accuracy is in the order of 0.005 mg. Many solutions have been analysed two or even three times, from which it is inferred that the *accuracy* of the colorimetric determination under the above mentioned conditions is as follows

> 2 % of the content of Fe_2O_3 for $Fe_2O_3 > 5$ %
> 5 % of the content of Fe_2O_3 for $Fe_2O_3 < 5$ %.

Manganese. The accuracy exceeds 3 per cent for the MnO_2 values above 0.1 per cent, and exceeds 10 per cent for values less than 0.1 per cent.

Nickel. The accuracy is about 3 per cent.

Verification of Solutions. Reliability of the Chlorine Extraction

The dissolution method of rendering silica insoluble has the advantage of being simple and not requiring expensive material. It is a convenient method for series analysis. It has the inconvenience of being lengthy and does not guarantee a total dissolution moreover, the silica-gel, by adsorption, always retains a certain quantity of metallic oxides.

Attempts have been made to shorten the method by working with higher temperatures in the sand bath. But if the dissolution process is carried out in less than 24 hours insufficient dissolution, of iron and specially manganese are obtained 24 hours, manganese and even iron may remain undissolved.

One sample out of ten has been submitted to an extraction control: two solutions, sometimes three, were prepared with this sample and colorimetrically analysed for iron, manganese and nickel. In this way the value of the reliability (error in extraction + error in colorimetric analyses) is obtained.

Two solutions of the same sample showed the following differences:

for Fe_2O_3: $<$ 6 per cent with a mean value of 3 per cent for a content of $Fe_2O_3 > 2$ per cent
$<$ 10 per cent with a mean value of 6 per cent for a content of Fe_2O_3 between 1 and 2 per cent
$<$ 15 per cent with a mean value of 8 per cent for a content of Fe_2O_3 of $<$ 1 per cent

for MnO_2: $<$ 10 per cent with a mean value of 5 per cent

for NiO: $<$ 10 per cent with a mean value of 5 per cent.

Efficiency of the Hydrochloric Dissolution

In order to find out the quantities of iron, manganese and nickel that may escape dissolution by the hydrochloric acid, three series of verifications were performed in the course of analysis:

a) Study of the siliceous residues which were submitted, either to a treatment by fusion with alkaline carbonate or to a hydrofluoric acid treatment.
b) Treatment of some samples by fusion with alkali carbonate
c) Treatment of some samples by Hydrofluoric acid.

The hydrofluoric acid treatment used by Correns (1935) for the chemical study of the samples from the Meteor is the best method. Unfortunately it is difficult to apply it to analysis of large series, which require 30 or 40 platinum crucibles which is generally impracticable for economic reasons. But this method remains the most favourable for control, as it makes possible a complete dissolution of the sample with a maximum of certainty. The fusion with alkaline carbonates also offers a good treatment, but economically it is open to the same objections, for only platinum or gold crucibles can be used. Furthermore, the alkaline fusion requires rather high temperatures and presents the disadvantage of adding to the solution considerable quantities of alkaline chlorides which ultimately have to be eliminated for the colorimetric determination of the manganese.

The three series »a», »b», »c» agree in showing that in nearly all cases the iron, manganese and nickel are almost entirely dissolved. In some rare cases, it is found that small quantities of iron or manganese exceeding 10 per cent of the total content are retained on the filter. These clearly incomplete solutions are easily recognized, as the siliceous residue on the filter is of a brown colour. Whenever this is observed, a supplementary solution is prepared by fusion with alkaline carbonates or by hydroflyoric

Average concentration in per cent

Core	$CaCO_3$	C	C*)	N	N*)	P_2O_5	P_2O_5*)	MnO_2	MnO_2*)	Fe_2O_3	Fe_2O_3*)	NiO	NiO*)
69	15.8	0.26	0.32	0.010	0.013	2.22	2.47	2.88	—	8.68	—	0.030	—
70	1.0	0.31	—	0.021	—	1.76	—	3.49	—	10.10	—	0.039	—
71	0.6	0.34	—	0.033	—	1.72	—	3.49	—	6.60	—	0.061	—
72	0.7	0.36	—	0.031	—	2.45	—	3.59	—	8.12	—	0.069	—
73	0.5	0.56	—	0.031	—	0.70	—	2.09	—	4.90	—	0.031	—
74	80.5	0.39	2.56	0.014	0.089	0.11	0.64	0.19	1.15	0.78	4.20	0.006	0.030
75	84.6	0.38	3.34	0.010	0.083	0.09	0.65	0.13	1.12	0.47	3.35	0.006	0.054
76	30.4	0.32	0.51	0.015	0.021	0.60	0.77	0.38	0.62	2.23	3.05	0.030	0.044
77	0.4	0.34	—	0.054	—	0.50	—	1.78	—	7.44	—	0.049	—
83	0.3	0.57	—	0.035	—	1.30	—	2.16	—	5.79	—	0.036	—
85	0.4	0.51	—	0.042	—	0.43	—	1.16	—	5.08	—	0.030	—
86	0.4	0.52	—	0.061	—	0.34	—	1.12	—	6.74	—	0.024	—
87	0.4	0.61	—	0.041	—	0.47	—	0.48	—	2.88	—	0.014	—
88	0.5	0.29	—	0.035	—	1.66	—	1.77	—	6.17	—	0.031	—
89	0.4	0.32	—	0.055	—	1.30	—	1.44	—	7.97	—	0.021	—
91	80.3	0.24	1.43	0.013	0.086	0.10	0.51	0.17	0.41	0.47	2.68	—	—
93	82.3	0.36	2.23	0.023	0.140	0.07	0.42	0.10	0.64	1.00	5.78	—	—
95	86.2	0.28	2.11	0.027	0.205	0.06	0.47	0.10	0.73	0.90	6.64	0.004	0.030
96	86.6	0.41	3.10	0.029	0.222	0.06	0.44	0.09	0.76	0.78	6.12	—	—
97	78.8	0.39	1.96	0.030	0.147	0.08	0.39	0.09	0.46	1.31	6.41	—	—
98	70.2	0.24	0.84	0.031	0.106	0.10	0.33	0.21	0.74	2.27	7.65	0.006	0.021
99	15.4	0.24	0.39	0.065	0.083	0.31	0.37	0.52	0.66	7.08	8.15	0.020	0.029
100	12.1	0.25	0.29	0.067	0.076	0.29	0.34	0.57	0.65	7.59	8.66	—	—
101	7.4	0.38	0.42	0.084	0.090	0.26	0.29	0.74	0.70	8.01	8.67	0.020	0.020
103	8.4	0.36	0.40	0.089	0.098	0.26	0.29	0.70	0.78	7.66	8.36	—	—
105	22.0	0.44	0.57	0.077	0.099	0.18	0.24	0.35	0.46	6.60	8.49	—	—
106	17.3	0.57	0.70	0.096	0.118	0.15	0.18	0.24	0.29	6.47	8.03	—	—

*) reduced to lime content = 0.

acid treatment. Usually, the siliceous residues contain less than 5 per cent of the total Fe_2O_3, less than 5 per cent of the total MnO_2 and less than 10 per cent of the total NiO. Considering the errors due to colorimetric analysis which are of the same order, the hydrochloric acid extraction is a satisfactory method though it gives too low results by a few per cent.

These tests have shown that hydrochloric solutions are unsuitable for titanium determinations: 30—70 per cent of the total titanium being found in the siliceous residue. The fusion with carbonates and the hydrofluoric acid treatment give a complete dissolution of the whole of Titanium minerals.

Corrections

Two kinds of corrections must be applied to the gross results: *Firstly a correction for the water content* to the values $CaCO_3$, C, N, P_2O_5. In order to avoid a possible destruction of organic matter, the determinations have been made with samples dried at 20° C (ARRHENIUS (1952). A correction is necessary for converting the values to sediment dried at 105°. For this purpose the value H_2O has been determined. H_2O gives the water content of sediment dried at 20° by comparison with the same sediment dried at 105°. There is a rather close relationship between H_2O and the content of $CaCO_3$: H_2O is of the order of 1 per cent in calcareous sediments; when the carbonate content decreases, H_2O increases gradually to a value of 6—8 per cent for sediments containing about 10 per cent $CaCO_3$. For red clays poor in $CaCO_3$, H_2O may exceed 10 per cent.

Secondly a correction for salinity. After being dried the sediment holds a certain quantity of salts soluble in water; this results from the evaporation of interstitial water. This salinity

of the sediment has been determined by titration of the chlorinity — according to the method of MOHR — from a solution originating from the digestion of about 0.1 g of sediment.

Expression of Results

The values $CaCO_3$, C, N, P_2O_5, MnO_2, NiO are expressed in percentage of *sediment dried at* 105° C *and free from salts*. Besides the gross values the reported percentages of sediment free from carbonates have been analogously calculated; they always figure on the diagrams when the carbonate content is high enough or sufficiently variable to obscure certain variations by effects of dilution.

These results are presented as diagrams; tables with figures would involve a cost not warranted by their usefulness. As for the cores from the East Pacific, it is possible to obtain primary values of analysis with the aid of the some punched cards which were used for the calculations. Duplicates of these cards may be obtained from the Oceanographic Institute, Box 1038, Göteborg 4, Sweden.

Furthermore, the diagrams include a representation of sediment colours according to the method of OSTWALD (1939).

References

ARRHENIUS, G.
1952. Sediment cores from the East Pacific. Sw. Deep-Sea Exp. 1947–48. Vol. V. Fasc. 1.

CORRENS, C. W.
1935. Die Sedimente des Äquatorialen Atlantischen Ozeans. Wiss. Erg. Deutsch. Atl. Exp. Meteor. Bd. III. 3 Teil, 1. Lief.

NYDAHL, F.
1949. Determinations of manganese by the peroxydisulfate method. Anal. Chim. Acta *3* 144.

OSTWALD, W.
1939. Die kleine Farbmesstafel. Göttingen.

SANDELL, E. B.
1944. Colorimetric determinations of traces of metals. Interscience. Publishers Inc. New York.

SVERDRUP, H. U., JOHNSON, M. W. and FLEMING, K. H.
1946. The oceans. New York.

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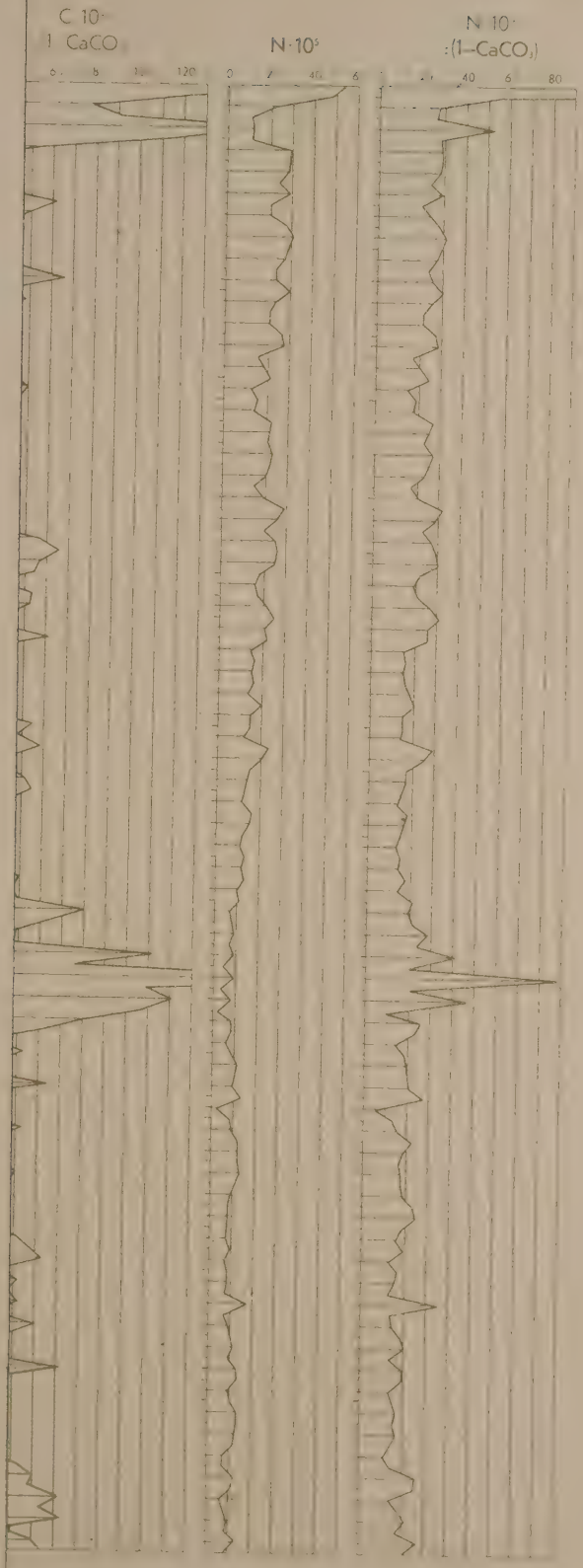

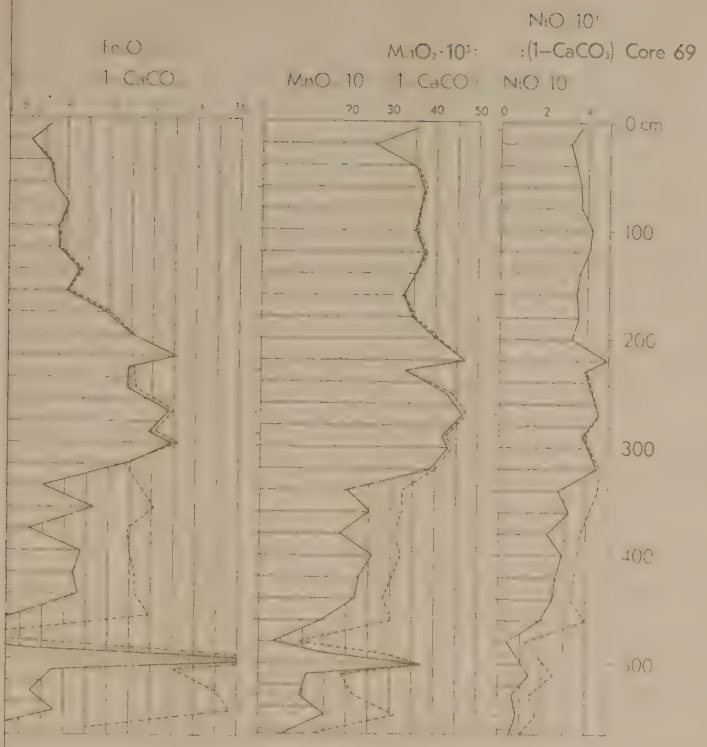
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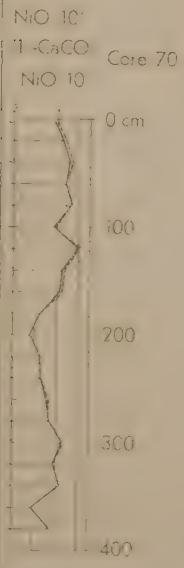
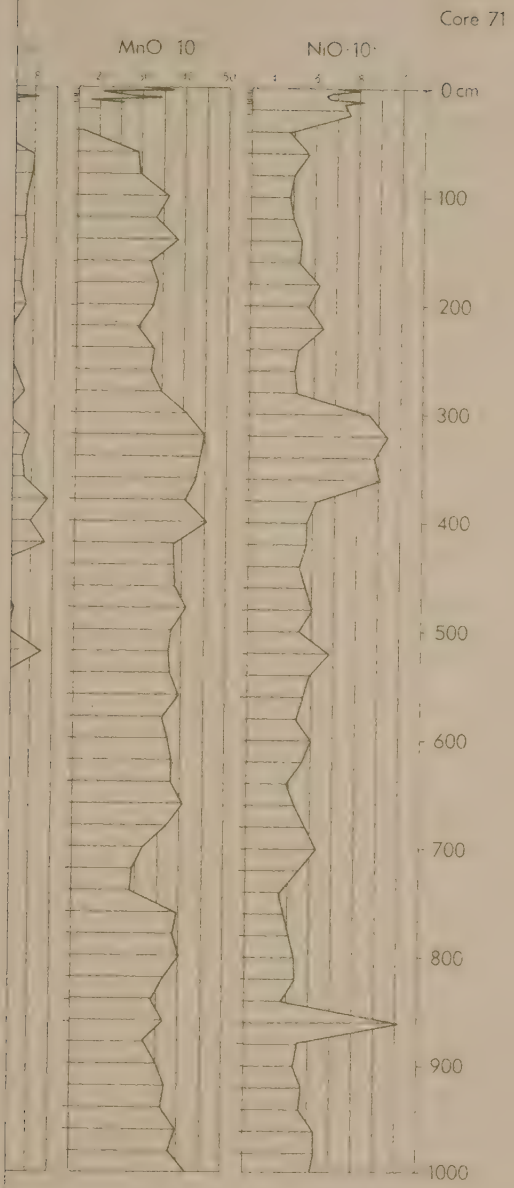
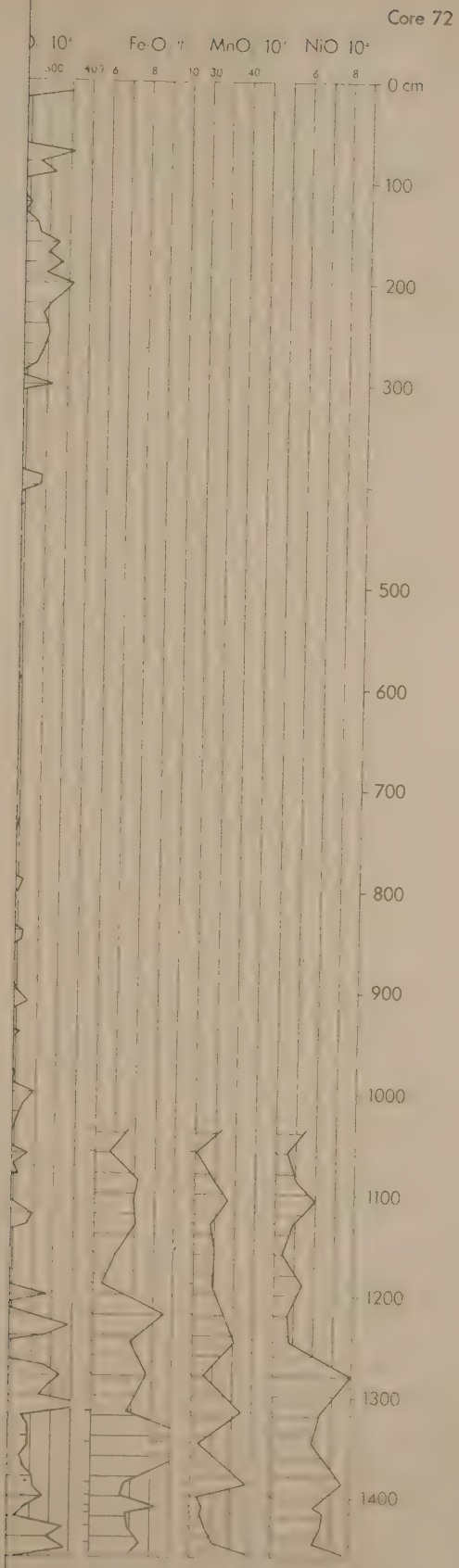
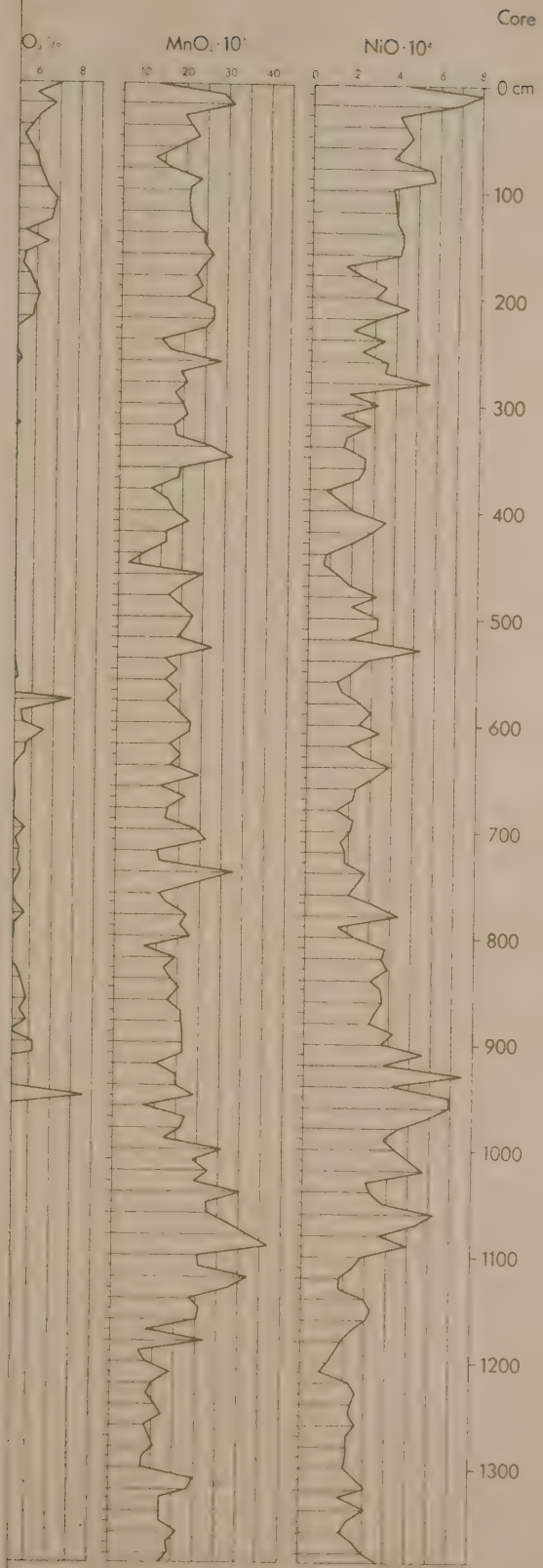
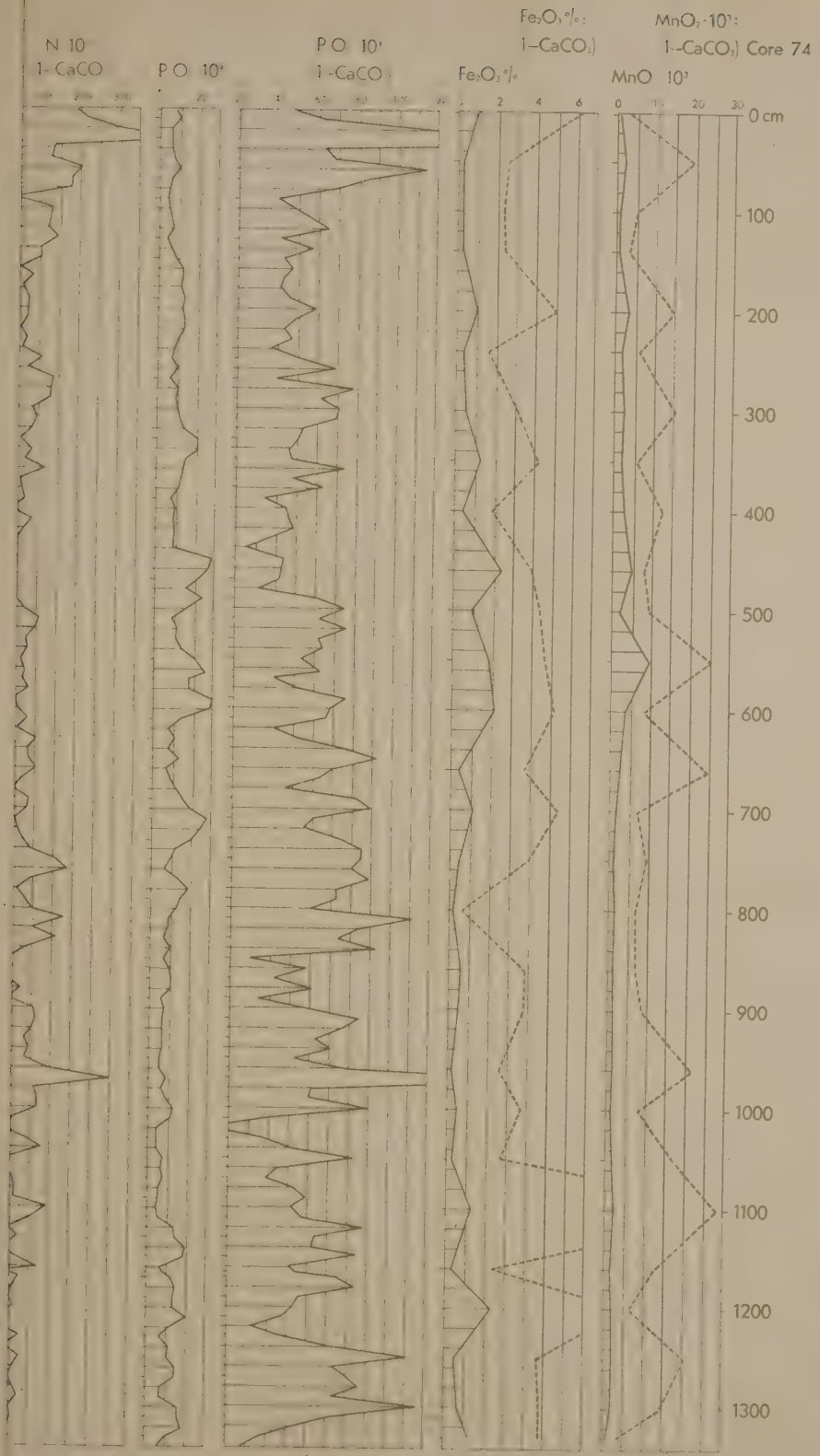
Fe O
Mn O₂ · 10³ :
:(1–CaCO₃) Core 69
1 CaCO
Mn O 10
1 CaCO
Ni O 10
20
30
40
50
0
2
4
0 cm
100
200
300
400
500

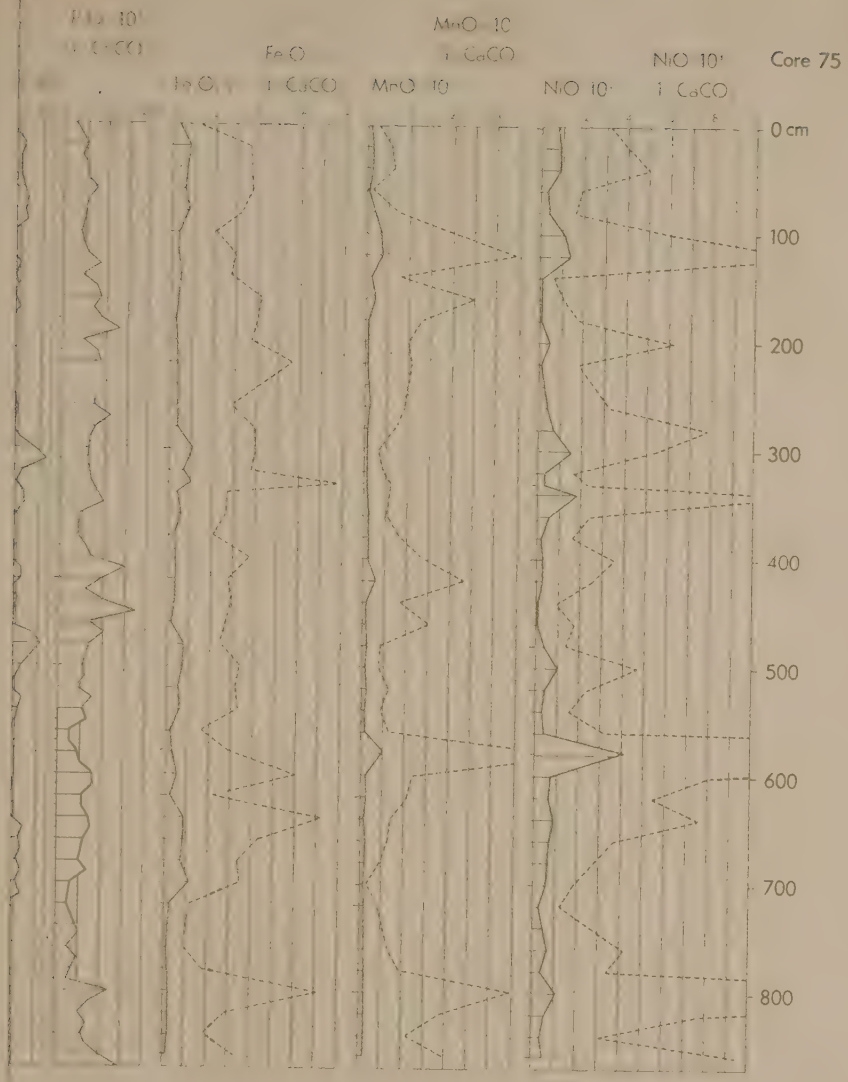

Ni O 10⁴
1 CaCO
Core 70
Ni O 10
0 cm
100
200
300
400

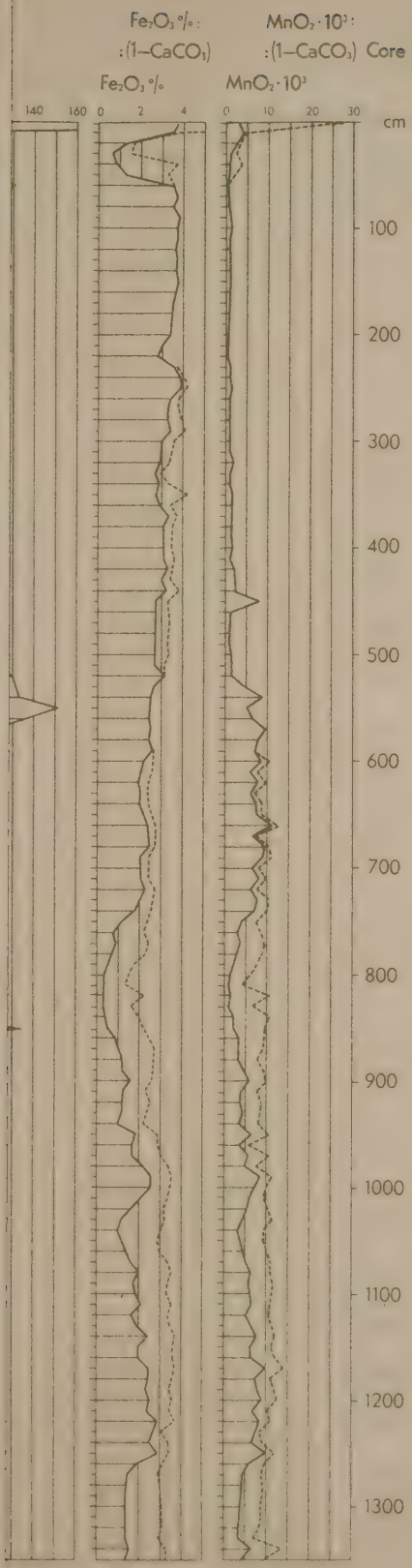

Core 71
MnO 10
NiO·10
0 cm
100
200
300
400
500
600
700
800
900
1000

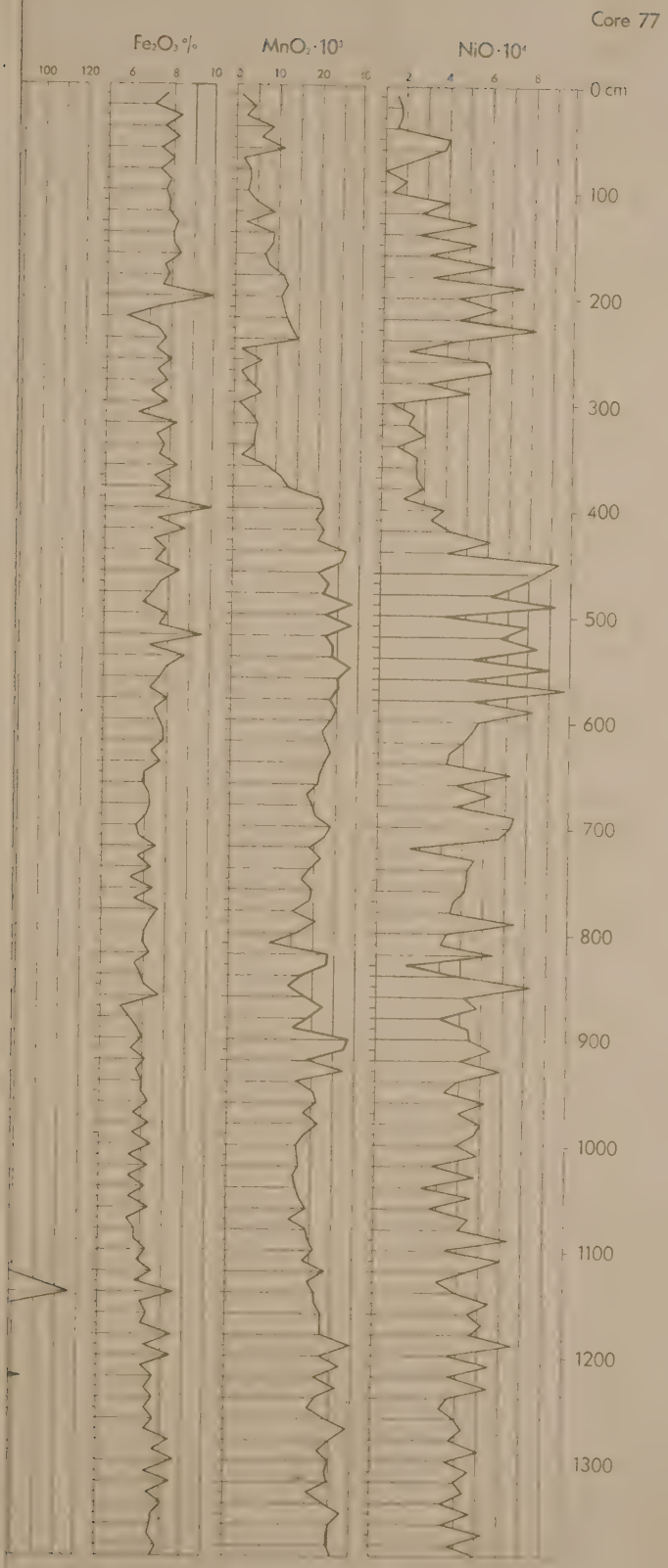

Core 72
Fe·O
MnO
NiO
0 cm
100
200
300
500
600
700
800
900
1000
1100
1200
1300
1400

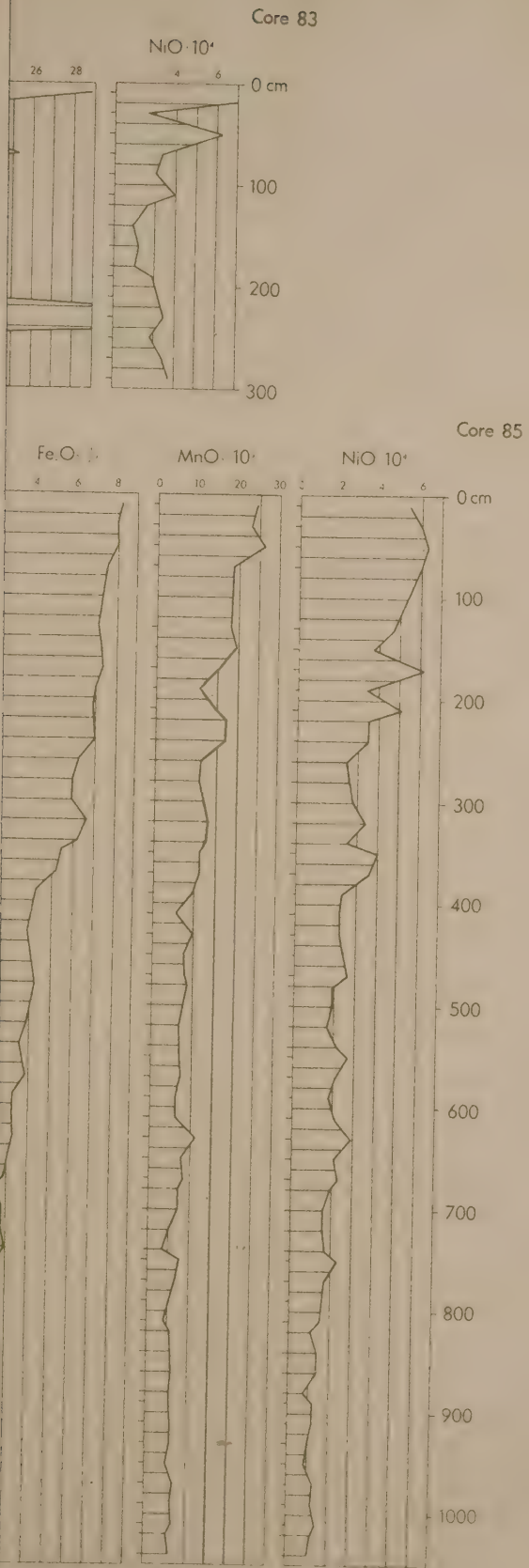

Core 73
MnO₂·10
NiO·10⁴
6
8
10
20
30
40
0
2
4
6
0 cm
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300

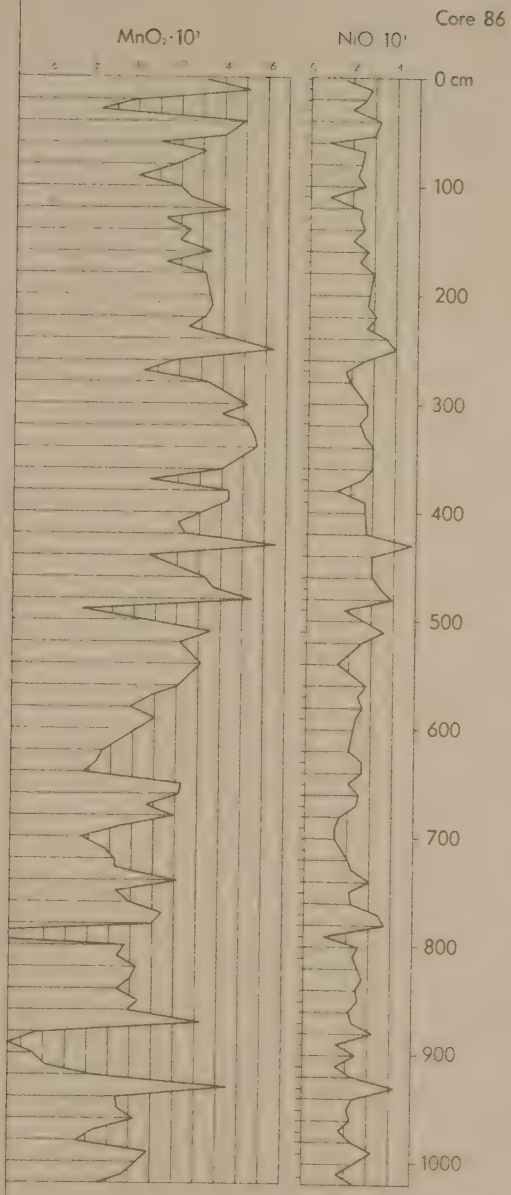

N 10
1-CaCO
P O 10⁴
P O 10⁴
1-CaCO
Fe₂O₃ %
Fe₂O₃ %:
1–CaCO₃)
MnO 10³
MnO₂·10³:
1-CaCO₃) Core 74
0 cm
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300

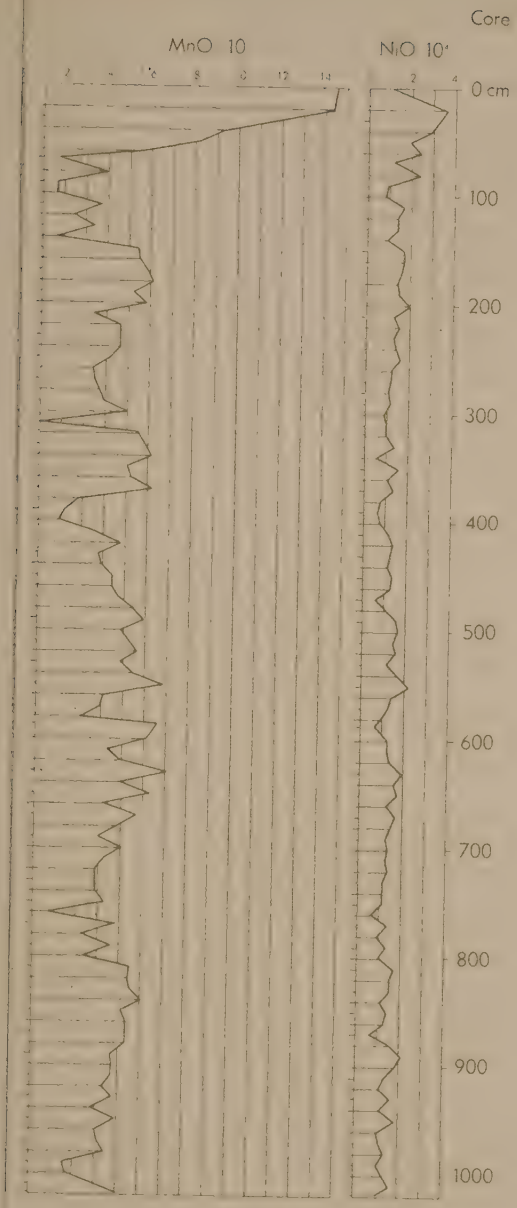

Fe2O3 10
1 CaCO3
Fe2O3
1 CaCO3
MnO 10
MnO 10
1 CaCO3
NiO 10
NiO 10
1 CaCO3
Core 75
0 cm
100
200
300
400
500
600
700
800


Fe_2O_3 % :
:(1–$CaCO_3$)
$MnO_2 \cdot 10^3$:
:(1–$CaCO_3$)
Core 76
Fe_2O_3 %
$MnO_2 \cdot 10^3$
140
160
0
2
4
0
10
20
30
cm
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300


Core 77
Fe_2O_3 %
$MnO_2 \cdot 10^3$
$NiO \cdot 10^4$
100 120
6 8 10
10 20
2 4 6 8
0 cm
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300

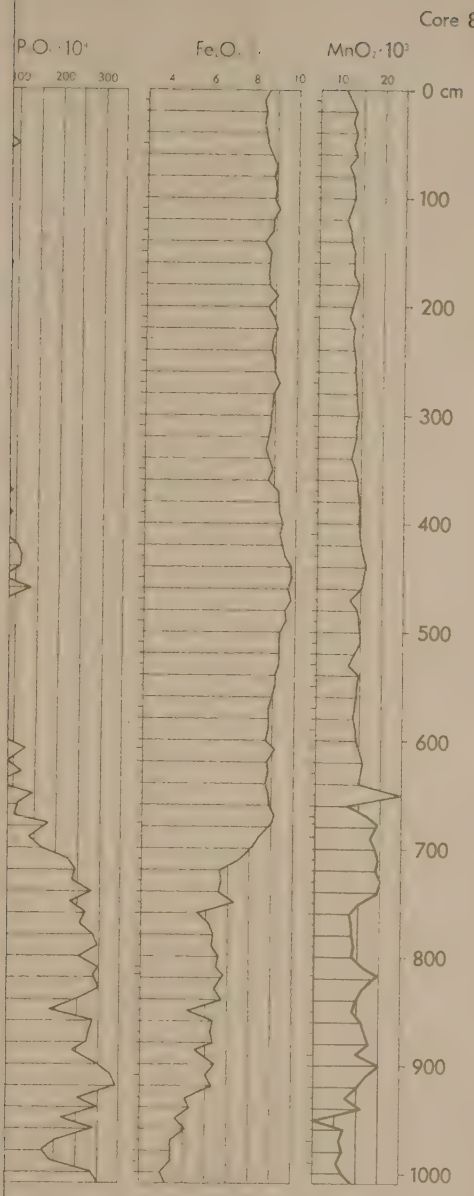

Core 83
NiO·10⁴
26
28
4
6
0 cm
100
200
300
Core 85
Fe₂O₃ %
MnO·10³
NiO·10⁴
4
6
8
0
10
20
30
2
4
6
0 cm
100
200
300
400
500
600
700
800
900
1000

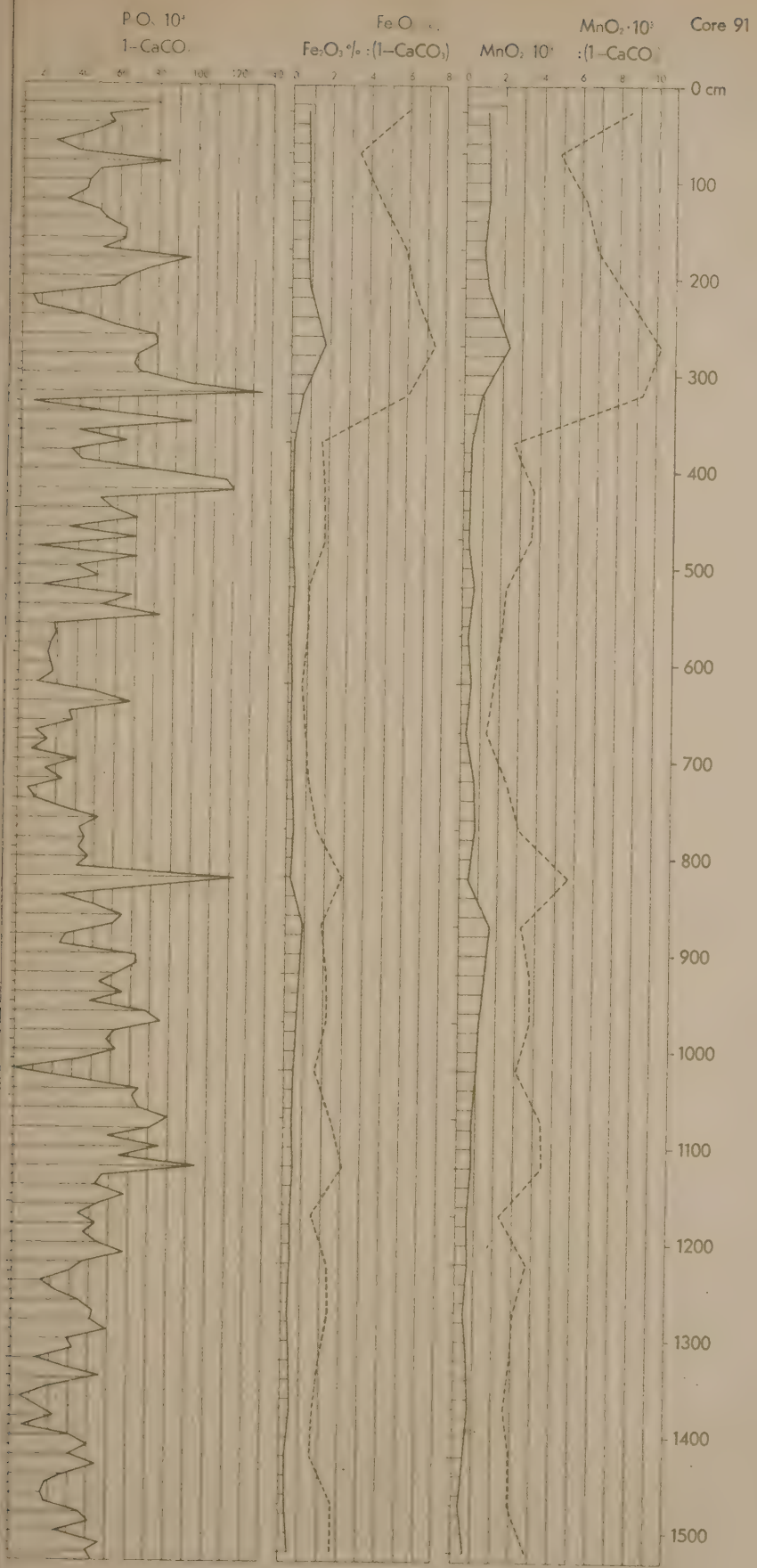

Core 86
$MnO_2 \cdot 10^3$
NiO 10^4
0 cm
100
200
300
400
500
600
700
800
900
1000

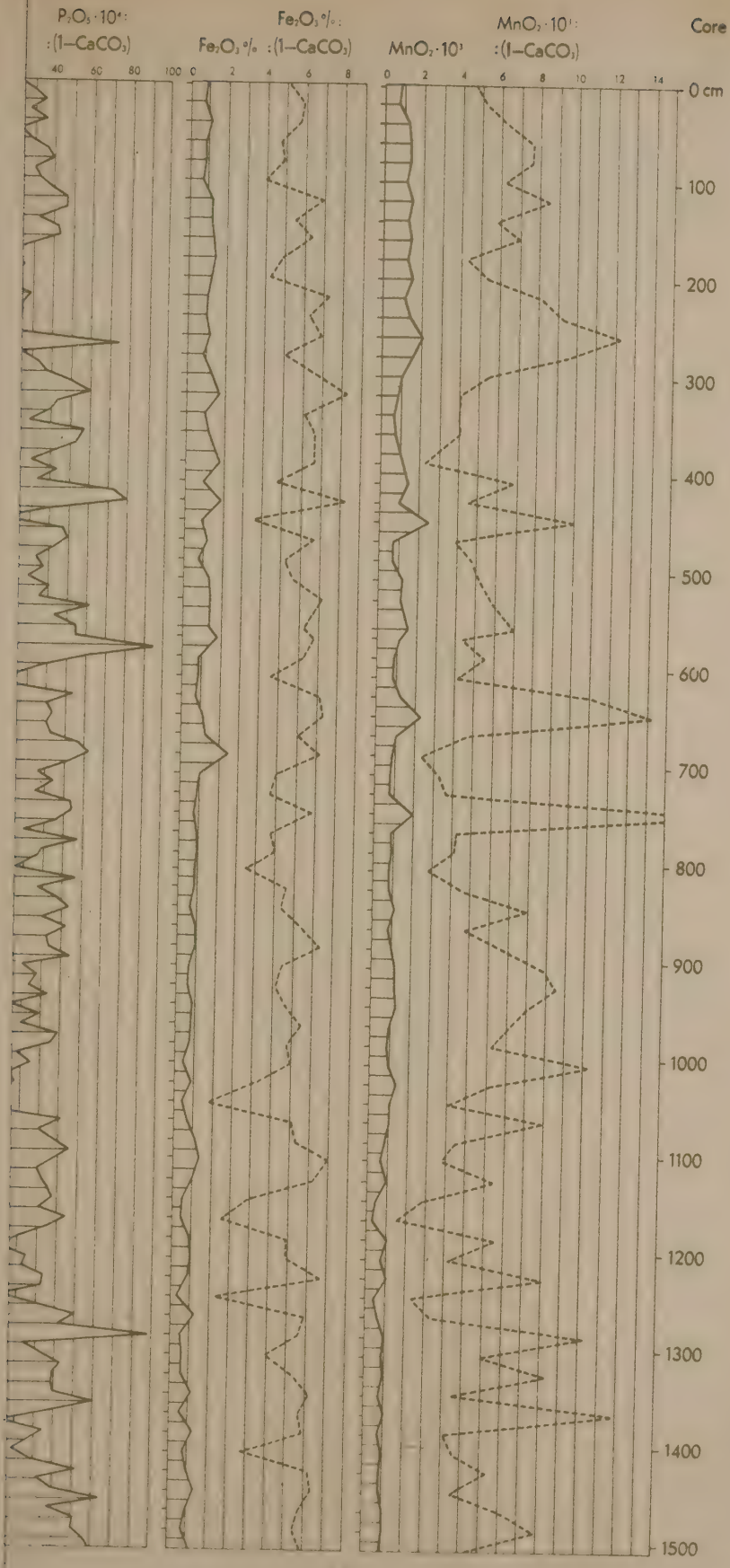

Core 87
MnO 10
NiO 10⁴
0 cm
100
200
300
400
500
600
700
800
900
1000

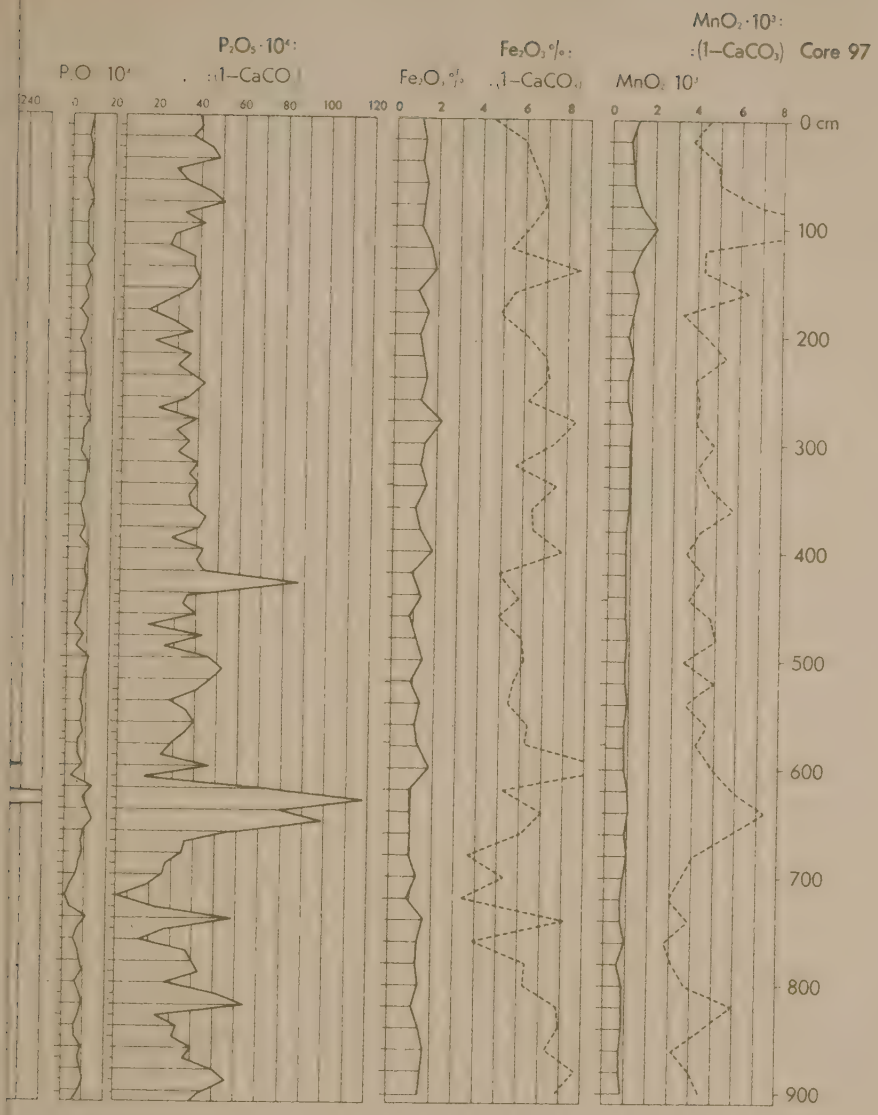
re 88

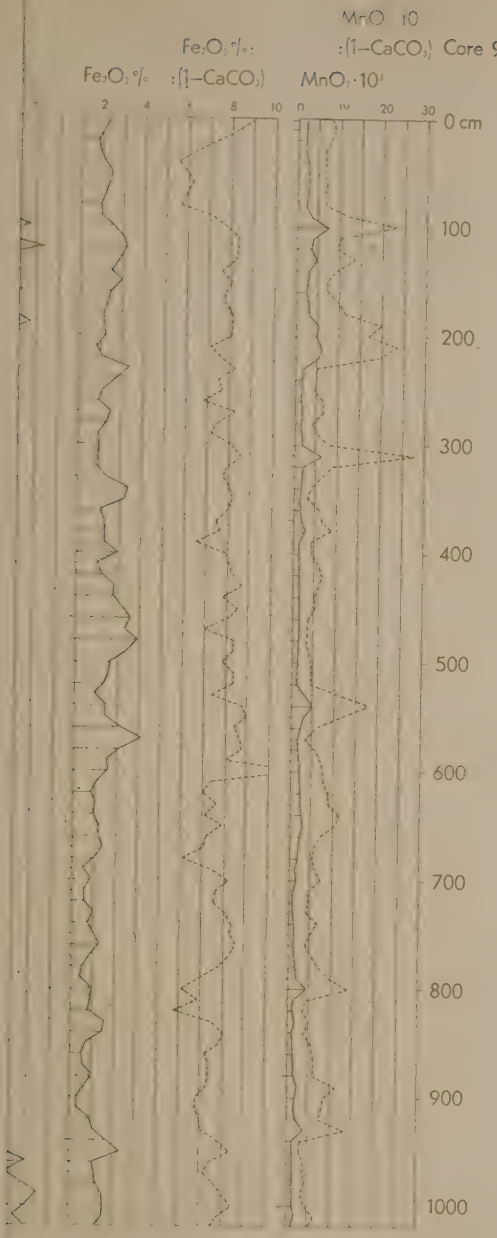
m

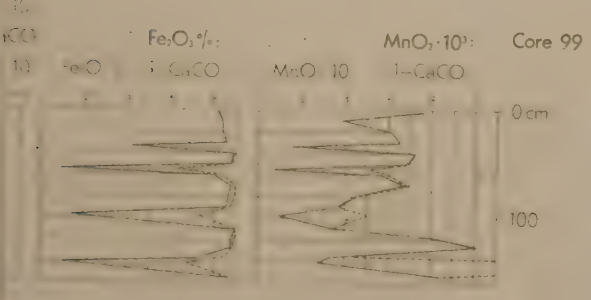

Core 89
$P_2O_5 \cdot 10^4$
100
200
300
Fe_2O_3
4
6
8
10
$MnO_2 \cdot 10^3$
10
20
0 cm
100
200
300
400
500
600
700
800
900
1000

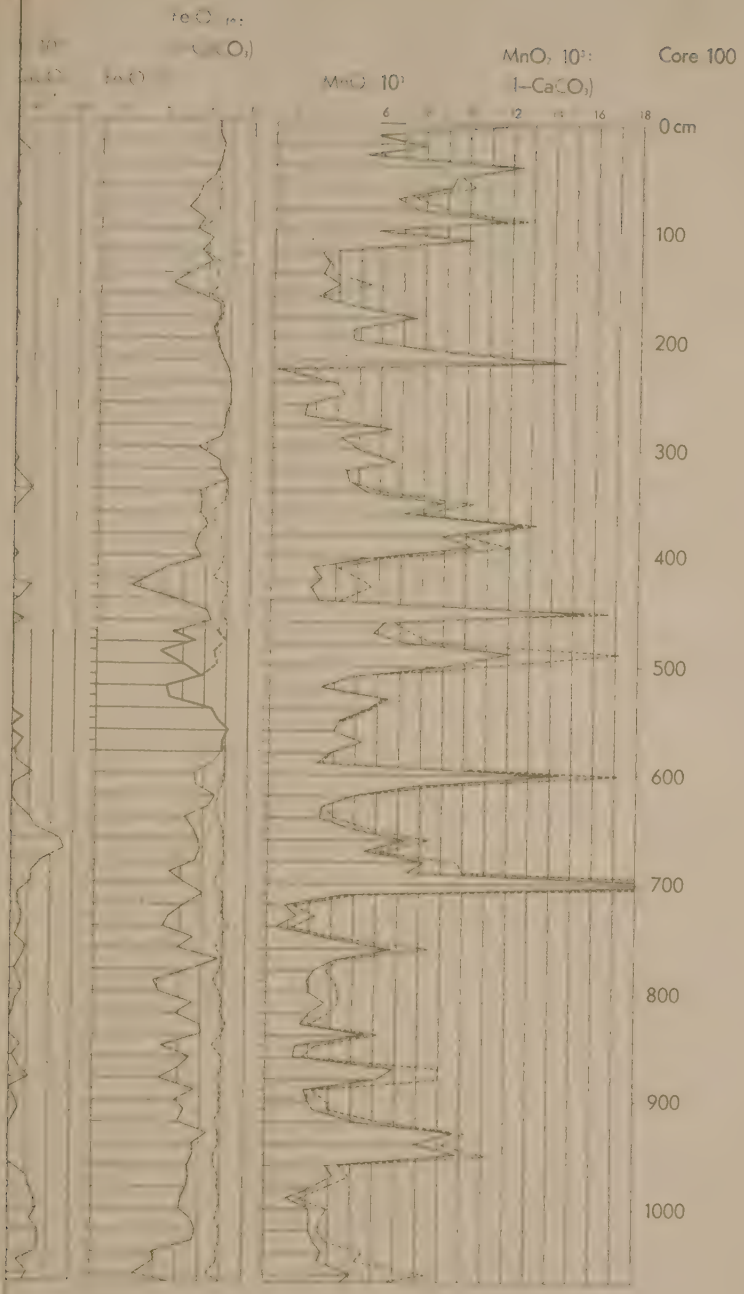

P O₄ · 10⁴
1 – CaCO₃
Fe₂O₃ %
Fe₂O₃ % : (1 – CaCO₃)
MnO₂ · 10³
MnO₂ · 10³
: (1 – CaCO₃)
Core 91
0 cm
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500

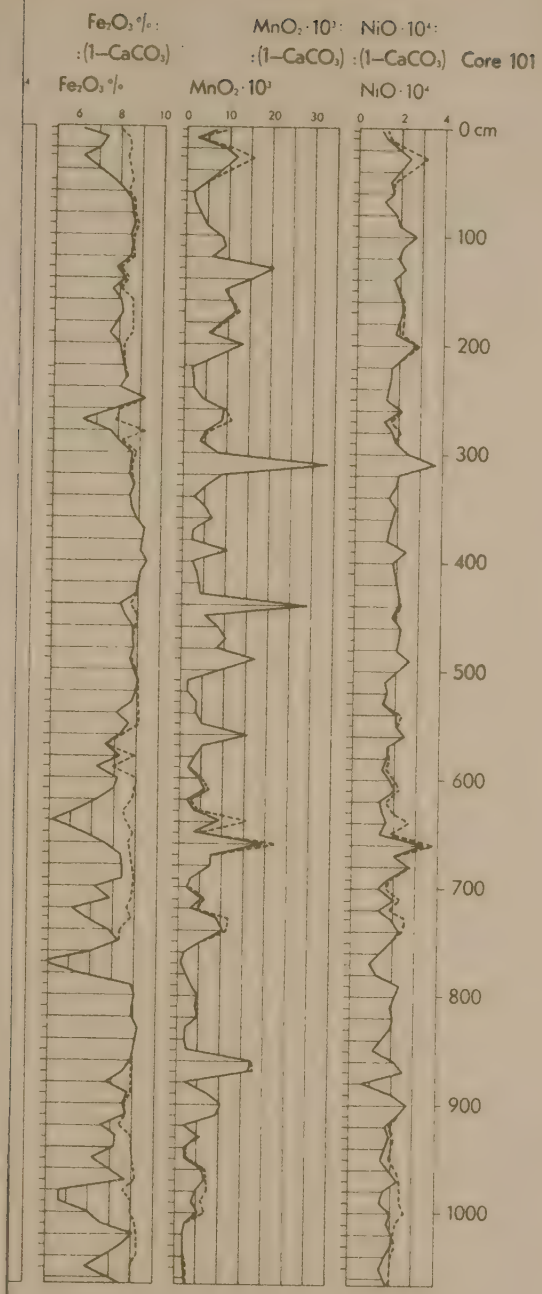

$P_2O_5 \cdot 10^4$:
:(1–$CaCO_3$)
40
60
80
100
Fe_2O_3 % :
Fe_2O_3 % :(1–$CaCO_3$)
0
2
4
6
8
$MnO_2 \cdot 10^3$
$MnO_2 \cdot 10^3$:
:(1–$CaCO_3$)
0
2
4
6
8
10
12
14
Core 93
0 cm
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500

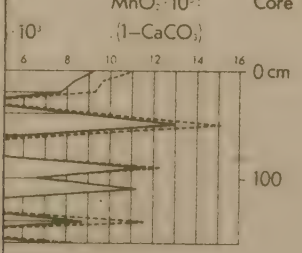

$P_2O_5 \cdot 10^4$:
$P_2O_5 \cdot 10^4$: (1–CaCO
Fe_2O_3 %
Fe_2O_3 % (1–CaCO
$MnO_2 \cdot 10^3$:
$MnO_2 \cdot 10^3$: (1–$CaCO_3$)
Core 97
240
0 20 20 40 60 80 100 120
0 2 4 6 8
0 2 4 6 8
0 cm
100
200
300
400
500
600
700
800
900

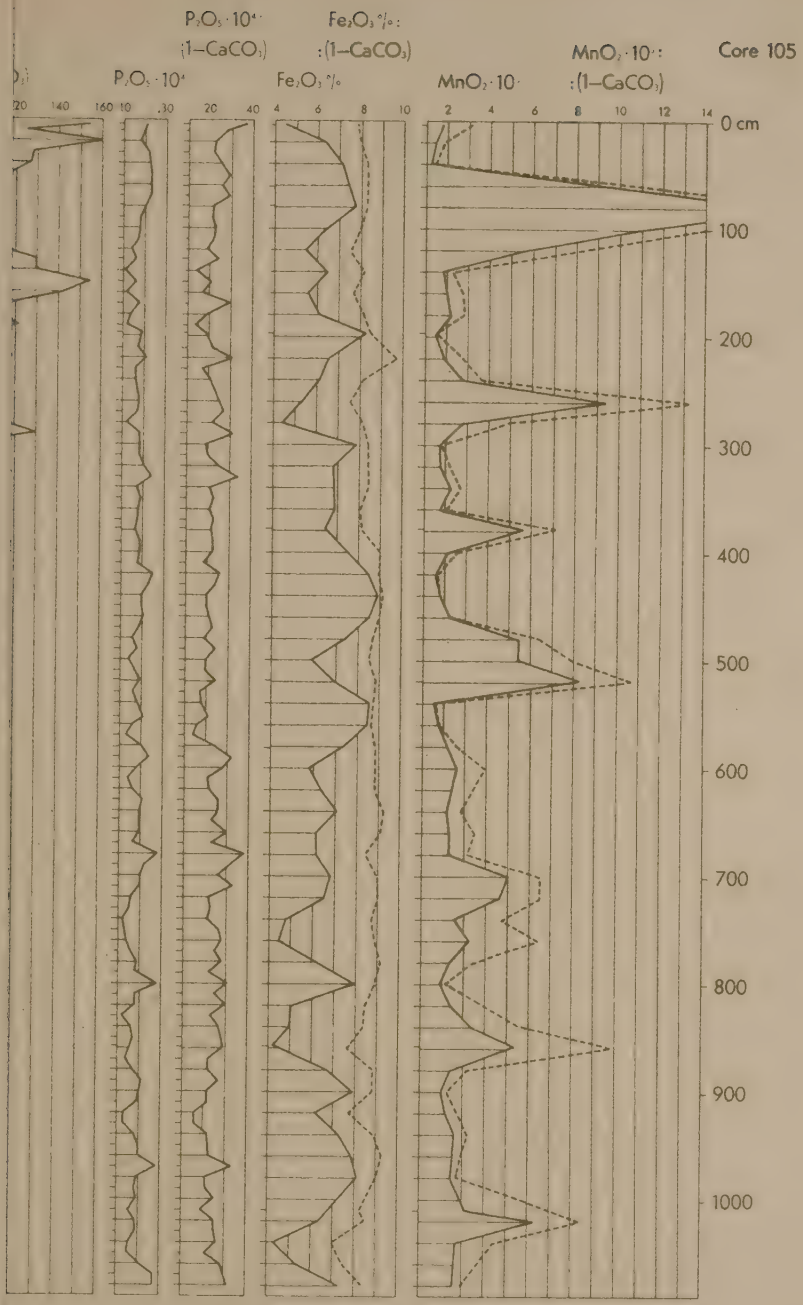

Fe2O3 %
:(1–CaCO3)
MnO2·10³
Core 98
0 cm
100
200
300
400
500
600
700
800
900
1000

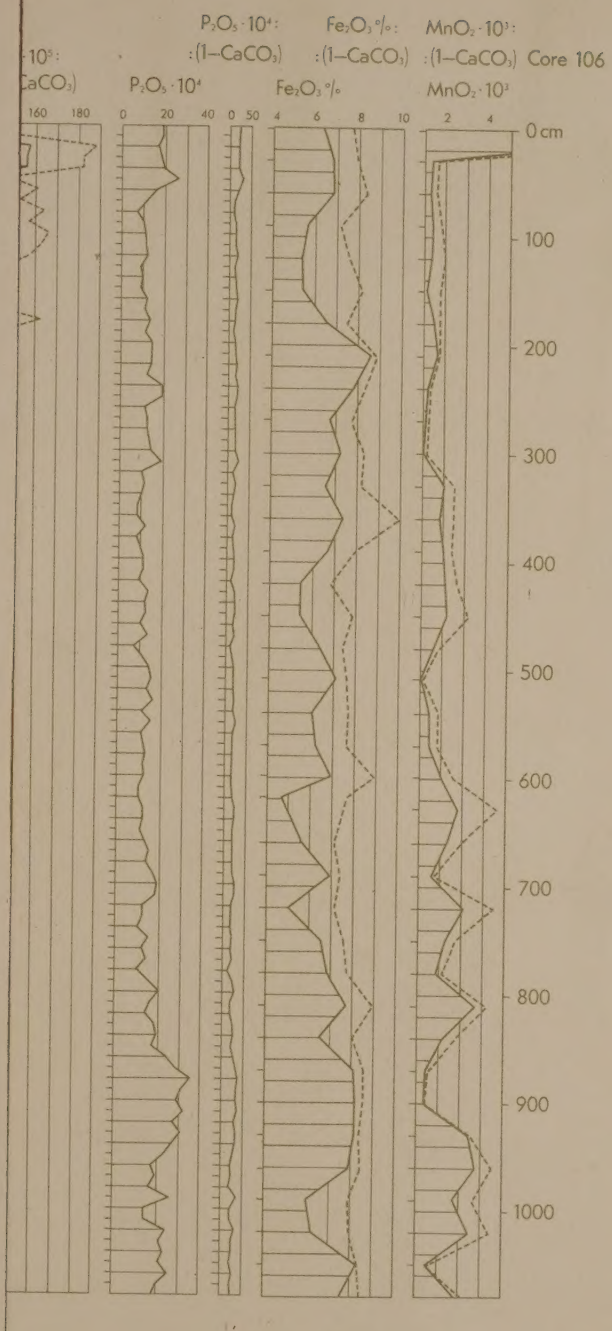

Fe2O3 %
MnO2·10³
Core 99
0 cm
100


MnO, 10³:
1–CaCO₃)
Core 100
6
12
16
18
0 cm
100
200
300
400
500
600
700
800
900
1000


Fe_2O_3 %/% : :(1–$CaCO_3$)
$MnO_2 \cdot 10^3$: :(1–$CaCO_3$)
$NiO \cdot 10^4$: :(1–$CaCO_3$)
Core 101
Fe_2O_3 %/%
$MnO_2 \cdot 10^3$
$NiO \cdot 10^4$
6 8 10
0 10 20 30
0 2 4
0 cm
100
200
300
400
500
600
700
800
900
1000


$MnO_2 \cdot 10^3$: :(1–$CaCO_3$)
Core 103
$\cdot 10^3$
6 8 10 12 14 16
0 cm
100


$P_2O_5 \cdot 10^4 : (1-CaCO_3)$
$Fe_2O_3\ \% : (1-CaCO_3)$
$MnO_2 \cdot 10 : (1-CaCO_3)$
Core 105
$P_2O_5 \cdot 10^4$
$Fe_2O_3\ \%$
$MnO_2 \cdot 10$
120 140 160
10 30
20 40
4 6 8 10
2 4 6 8 10 12 14
0 cm
100
200
300
400
500
600
700
800
900
1000


$P_2O_5 \cdot 10^4$:
$(1-CaCO_3)$
Fe_2O_3 %
Fe_2O_3 %
$MnO_2 \cdot 10^3$:
$(1-CaCO_3)$
$MnO_2 \cdot 10^3$
Core 106
160 180
0 20 40
0 50
4 6 8 10
2 4
0 cm
100
200
300
400
500
600
700
800
900
1000

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